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THE CERIUM METAL AND LIGHTER FLINT INDUSTRY IN GERMANY AND AUSTRIA.

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THE CERIUM METAL AND LIGHTER FLINT INDUSTRY IN GERMANY AND AUSTRIA

BY

JOHN A. LIVINGSTON

AND

HENRY KENT

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DEC 2 1952
U.S. PATENT OFFICE

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ABSTRACT

This report describes processes employed in manufacturing cerium (misch) metal and ferro-cerium lighter flints. Information is also given in regard to the use of cerium (misch) metal in alloys. Some statistics are given concerning production of these materials.

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TABLE OF CONTENTS

Subject	Page
Introduction	5
Auergesellschaft, Berlin	5
Berliner Gasglühlicht Werke	6
Th. Goldschmidt A. G. Essen	6
Prometheus Kempten Im Allgacu, Bavaria	8
Pyrophor Metallgesellschaft A. G. Essen-Werden	10
Treibacher Chemische Werke A. G. Treibach-Kaernten	11
I. G. F. Bitterfeld	13
Appendix 1 List of German Personnel Interviewed	17
Appendix 2 List of Targets Visited	18
Appendix 3 Bibliography	18

INTRODUCTION

Objective:

The object of the authors in investigating this field was two-fold.

1. To study the methods employed in the manufacture of cerium (misch) metal and lighter flints, including the processing of the raw materials, beginning with monazite sand.

2. To find out for which purposes other than lighter flints, cerium was used or might be employed.

Evaluation:

In regard to item 1. a number of plants were visited where cerium (misch) metal and lighter flints had been made in the past. However, no plants visited were in production due mainly to the lack of raw material and equipment. This report, therefore, is based largely on information obtained from the people interviewed and does not represent the actual knowledge or experience of the authors.

Concerning item 2. apparently thought was given to the use of cerium in special alloys during the war but research was deferred in most cases when it became clear raw materials would be lacking.

Guide to the Reader:

The subject matter in this report is preceeded by a short summary, then each target visited is separately discussed. The information on the I. G. F. practice at Bitterfeld was furnished by Mr. B. Wilcoxon of the Miscellaneous Chemicals Unit.

Summary:

The following factors stand out in the minds of the authors in reviewing their experiences and investigations in this field:

1. All manufacturers of cerium (misch) metal and lighter flints were dependent upon one company, the Auergesellschaft, for their rare earth chloride.

2. The difference in opinion amongst the persons interviewed as to the relative advantages of vacuum dried chloride as against chloride dried in air.

3. The almost universal use of electricity for melting and heating purposes.

4. Little cerium misch metal was used for purposes other than for making flints.

5. Practically no pure cerium metal was produced.

AUERGESELLSCHAFT BERLIN N 65
FRIEDRICH-KRAUSER UFER 24

(13 July and 13 Aug. 1946)

This target has combined with the Berliner Gasgluchlicht Werke, formerly Richard Goetachke A. G. The latter company is discussed in a separate report.

The Auergesellschaft Plant in Berlin had lost most of their records and equipment and materials at the time of the fall of Berlin. Their principal plant at Oranienburg had also suffered losses of records, equipment, materials and personnel, therefore the information given in this report was gained only through conversations with remaining personnel.

In normal years, as for example 1938, Auergesellschaft used about 1400 tons of monazite sand from which they supplied rare earth chloride to the following manufacturers of cerium misch metal:

I. G. Bitterfeld	about 150 tons
Treibach Chemical Works	about 150 tons
Prometheus	6 tons

Siemens, Berlin received about 60 tons of cerium fluride which was used for the manufacture of electrodes for searchlights.

The rare earth chloride supplied to I. G. Bitterfeld and Treibach Chemical Works was anhydrous. The wet chloride was dried by Auergesellschaft in a vacuum type dryer. Three dryers were in operation and consisted of steam heated rotating iron drums operating at about 350° C with a vacuum of 700. The dry chloride was in the form of a white powder and was supplied in airtight containers. The oxychloride content was about 1½%.

No plans or details of the drying process were available.

BERLINER GASGLÜHLICHT WERKE
RICHARD GOETACHKE A. G.

(13 July, 1946)

This target has combined with the Auergesellschaft. They had been competitors and both worked monazite sand and manufactured rare earth compounds. Auergesellschaft is described in a separate report.

Goetachke had just completed a plant for the manufacture of cerium metal and lighter flints. The plant is in Oranienburg and has been seized by the Russians.

Goetachke manufactured their own rare earth chloride from monazite sand and dried by a vacuum process. The drying was done in two stages. In the first stage a horizontal rotating drum was used, employing superheaded steam at 350° C. The drum was of iron, about 60 cm in diameter and contained two shells. The second container was stationery and was heated to 175° C. by steam coils around the outside of the container. The entire drying process took about four hours. About 250 kilos was dried at a time. The dried chloride came out in powder form and was stored in airtight containers.

The above description was given from memory by Mr. Paetsch, and he did not seem to recall the details very clearly. He installed but did not operate the equipment. No plans or specifications were available. The men in charge of the operation of the equipment were not available. Dipl. Ing. GOERZ lives at QUERFURT, Joh. Schlaf St. 15. Dr. Weissenborn has died. Querfurt is in Russian Zone.

Little or no information was available regarding the manufacture of cerium metal or flints.

It was stated that the flints were to be manufactured by means of KOKILLEN, or split moulds. These moulds were described as being made of a special cast steel, composition unknown. Each half form was about 250 mm high, 200 mm wide and 18 to 20 mm thick. They contained about 16 vertical grooves, semi-circular in shape, of the diameter of the flints to be cast. The grooves were 10 mm apart, center to center. They were assembled, eight plates to a mould by means of 4 tightly fitting bolts, 8 mm diameter. Each mould therefore had about 128 grooves.

The moulds were heated to about 750° C and the molten ferro-cerium pounded into the mould. No one present knew how this operation was done. The method is believed to follow in principle, but on a smaller scale, the method employed by Pyrophor Metallgesellschaft, Bitterfeld.

Our attention was directed to the following for additional information on the subject:

Prometheus
Kempten im Allgaeu
Bavaria

Mr. Meier - Oswald
Kempten im Allgaeu
Kronprinzen Str. 4

TH. GOLDSCHMIDT A. G. ESSEN, GERMANY
HEILERMANNSTR. 15

(11—15 July and 19 Aug. 1946)

We first called on Dr. Theo. Goldschmidt, President, who was very co-operative. Dr. Goldschmidt explained to us that his company had an interest in the Treibacher Chemische, Austria, and had operated this concern during the war.

After discussing briefly the subjects of cerium, cerium alloys and the other rare earth metals, Dr. Goldschmidt made arrangements for us to see some of his employees who specialized in metals and had a knowledge of this subject.

As arranged by Dr. Goldschmidt, we discussed the subject of cerium alloys with Dr. Schertel and Prof. Bungardt. It was decided that these gentlemen would endeavour to obtain concrete information on the subject for us and arranged for a later meeting which took place on 13 July.

Attached hereto is a tabulation of data received from them showing the results of tests made by I. G. Farben at their Bitterfeld Plant on various alloys of the composition indicated:

TABLE 1

Experiments with Magnesium Sheets (1 mm Thick)

Name.	Composition	Yield limit Kg/m²	Tensile strength Kg/m²	Elon-gation %	Deep test Ericson mm	Min. folding radius 90%
AM 503	2% Mn Balance Mg	11	21	7.5	2.5	5—6 X thickness
AM 537	Same but with 0.2—0.5% Ce	18	24	18	3.8	3.5—4 X thickness
Za	No Ce with .7% Zr	19	23	22	4	2.5—4 X thickness

Note: Sheets made with 2% Mn and 0.2 — 0.5% Ce showed tendency to crack. This was remedied by addition of 1% Al.

TABLE 2

Experiments with Magnesium Forgings.

(Extruded Test Bars 25 mm Diameter.)

Name	Composition				Yield limit Kg/m²	Tensile strength Kg/m²	Elon-gation %	Fatigue limit KG
AM 503	2% Mn	2% Fe	2.2 Si		15	22	2	7
AM 537	2% Mn			.4% Ce	24.8	28.7	8.4	9—10
AM 1	2% Mn			1.5% Ce	31	32.5	10	—
AM 2	2% Mn	0.6% Zn		.4% Ce	29.3	31.9	7	10
AM 3	2% Mn	1% Cd		.5% Ce	27	31	17	—
ZA 1		.7% Zr			27.5	30	15.8	8—9
ZA 2	.3% Zn	.9% Zr		.2% Cd	29	33	12	—

Note: Fe and Si were impurities — not additions.

TABLE 3

Creep Resistance @ 140° C

Mg	5 Kg/m²
Mg —5 to 6% Ce	11 Kg/m²

We next discussed the use of cerium as an addition agent to nickel and chromium alloys to increase the durability and life of heat resistance electric coils and wires made from these alloys.

While the results of the experiments made in this field have been promised they were also not uniform and due to this, plus the lack of raw materials, the tests were not completed and the process was not employed in a practical manner. These experiments apparently were made by the Krupp people. In general the alloys contained approximately 80% nickel and 20% chromium.

Mention was also made by us of the subject of powdered cerium and using same for tracer bullets. Dr. Schertel or Prof. Bungardt had no knowledge of this subject but Dr. Schertel promised to look into this matter.

On 19 August information was received that as far as was known powdered cerium was used only experimentally for tracer bullets. Some experiments had been made but no advantages were shown over known and tried materials.

Powdered cerium has been used for incendiary shells but these shells were destroyed in a large fire while being loaded at the shipping terminal.

No information was available as to how the powdered cerium was manufactured or stored.

It was stated in general that cerium showed no particular advantage for the uses referred to above.

Th. Goldschmidt A/G. is listed as the owner of British Patent 266,696. This patent among other things made reference to the use of cerium in aluminum bearings. It was stated that this patent has found no practical application as far as the use of cerium is concerned.

Dr. Goldschmidt also volunteered the information that to his knowledge experiments had been made by the Vereinigte Leichtmetallwerke GMBH at Hannover in connection with use of cerium in light metal alloys similar to duraluminum. The leading technician of this company, Dr. Brenner, is said to be in England.

PROMETHEUS KEMPTEN IM ALLGAEU, BAVARIA, GERMANY.

27 July 1946)

1. History

Prometheus has been manufacturing flints for 25 years. The International Cartel assigned them a production of 1000 kgs. annually. They are not manufactured now due o lack of raw materials and equipment.

2. Drying of Rare Earth Chloride:

This company purchased hydrous rare earth chloride rom Auergesellschaft, Berlin. They did their own dryng. A description of their drying process follows:

Two electrically heated furnaces were used (resistance eating). The furnaces were built up of sheet metal mm thick, conical in shape, having a height of 600 mm, per diameter of 850 mm. and bottom diameter of 0 mm.

Two types of dry chloride are produced, one type for rting the electrolysis and another for normal operation:

Starting composition:

15 kilos $CeCl_3$ + 20 kilos $CaCl_2$

Normal composition:

30 kilos $CeCl_3$ + 2 kilos $CaCl_2$

The hydrous chloride is slowly heated so that the drying process takes between 2 and 2½ hours. No definite figures as regards temperature were given. It was stated that this was a matter of experience and the process was a compromise between temperature and time. The anhydrous chloride forms in sheets about ½ inch thick and is broken into pieces before removing and then stored in airtight drums.

The total production of anhydrous chloride per furnace is about 240 kilos per day. About 32 kilos wet chloride produce about 20 kilos of the dry or anhydrous material.

Electrolosis of cerium misch metal:

There are six electrolyzing cells of the same dimensions and characteristics.

The cells are built of sheet metal about 1/4 inch thick. They are conical in shape 450 mm high and having an upper diameter of 350 mm and bottom diameter of 250 mm. The insides are lined with a mixture of fire-clay and cement. The lining is 25 mm thick at the upper end and tapers to 40 mm at the lower end. The bottom is also lined with the same material having a thickness of about 40 mm.

At the top there are three electrodes (anodes) made of Siemens Electrographite. These electrodes are 100 mm in diameter. At the bottom of the cell there is an iron cathode 100 mm in diameter.

The cells are operated at 1500 amperes, 12 volts and all six are placed in series.

To start the operation five of the cells are cut out and the remaining cell is started by arcing the cathode and one anode. The anhydrous chloride (starting mixture) is added and then the other anodes are put into operation. The remaining cells are successively started in the same manner. After that, the normal mixture of anhydrous chloride is added and additional quantities are added every hour.

Each 24 hours the metal is removed by tilting the crucibles. The molten chloride is poured back into the crucibles and the process continues as originally. After 100 hours the cells are shut down for the weekend and started up again the following Monday.

In 100 hours the six cells produce about 800 kilos of metal.

It is estimated that 2.8 kilos of anhydrous chloride produce one kilo of cerium misch metal. The cerium misch metal contains up to 12% iron.

Manufacture of flints:

Flints are not cast into tubes in the conventional way but are made in kokillens or split moulds. The composition of the metal is as follows: Iron 15 to 18%, zinc 2%, copper 2%, magnesium 2%, balance cerium misch metal.

The kokillens are built up of individual cast iron plates approximately 15—3/4 inches high and 4 5/8 inches wide in which there are 28 semi-circular grooves 2.6 mm diameter. Thirteen such units are pressed together to form one mould thus providing 12 rows of grooves for each set of moulds.

The individual plates are pre-heated to about 500° C in an electric furnace and before being removed from the furnace they are clamped lightly together by means of a clamp.

The mould is then transported by a pulley arrangement into a holding device where the individual plates are firmly pressed together and fitted into a tightly fitting head. This head is then connected to a container which in turn is connected with a vacuum pump.

In the meantime, the alloy from which the flints are to be made is heated in a graphite crucible placed in a bath of pure sodium chloride and heated up to a temperature of about 850° C. Heating is done by electricity.

When ready for use, the crucible is taken out, the salt cover is removed and the crucible is put into a small wagon-like device which is then rolled under the mould.

Almost simultaneously the crucible is pressed up against the bottom of the mould by a lever device, the vacuum system is put into operation and the metal is sucked up into the mould. It was stated that a vacuum of 90% is used. After a few minutes the mould is removed, the individual plates are readily separated and the flint rods can then be removed.

Each mould contains about 3 1/2 kilos of flints and 12 casts are made per day. It was stated that each mould could be used from 200 to 300 times.

General:

In view of the comparatively small output this plant can be operated very efficiently.

The entire production can be made by four workers, namely, the technical manager and three assistants. The electrolosis is only done during two or three months of the year when there is plenty of water available for electric power and when the current can be purchased very cheaply. At this time two 12-hour shifts are run. The technical manager operates the cells during one shift and another man does the drying. In the second shift at night there are also two men, one for operating the cells and the other for operating the dryers. In this way, in the two to three months enough metal is made for the entire requirements of the plant for twelve months.

When the metal production is finished, the same men produce the flints in the remaining months.

The company employs additional help for cutting, sorting, coating and packing the flints. This whole process was developed gradually over a period of 25 years and is entirely dependent on the skill and knowledge of the technical manager. No drawings of equipment were available as they all were developed piece by piece and built in their own shops.

PYROPHOR METALLGESELLSCHAFT A. G.

ESSEN-WERDEN, GERMANY

(13 July 1946)

Visited the plant at Essen-Werden and found target completely destroyed with some damaged machinery in the wreckage. Machinery seemed to be equipment for making and labelling containers for flints.

We found an address on gate of building as follows:

Ruhrtal Str.

Mr. Bernhard Pilz

and called on Mr. Pilz on 13 July.

Mr. Pilz informed us that he was and still is the commercial director of this company. In this capacity he claimed no technical knowledge of process employed. He stated he had seen, a number of times, the processes employed and would try to recall same and answer our questions to the best of his knowledge and recollection.

He stated that flints were made at this target from 1919—1927, the metal having been obtained from the Bitterfeld Plant of I. G. Farben. The process employed at that time was similar to that developed by the Treibacher Chemische Werke A. G., Treibach, Austria. He claimed not to know much about the details except that the flints were cast in sheet metal tubes.

From 1927 on, the flints were made at Bitterfeld. Although Mr. Pilz had seen the Bitterfeld process for making flints on various occasions, his recollection was very poor or he did not care to give us the information.

According to Mr. Pilz, the Bitterfeld process is quite different from the process used at the Werden Plant prior to 1928. The ferro-cerium is cast into moulds approximately 37 cm. in width, 50 cm. long and 20 cm. thick. He did not know the type of metal which these moulds were made of. The moulds were made in halves having vertical semi-circular grooves along the length and the two halves were fastened together by screws. Each complete mould contained only one row of these grooves. As far as Mr. Pilz could recall, there were between 70 and 80 grooves in each mould.

The moulds were placed on the ground and heated by gas to between 1000 to 1200° C. The molten ferro-cerium was poured slowly into these grooves. According to Mr. Pilz, the bottom of the grooves was closed and he could not explain how the air escaped during casting. After casting the moulds were cooled by streams of air.

The ferro-cerium was melted in graphite crucibles but Mr. Pilz had no recollection as to the amount of metal which each crucible contained. He thought that each crucible contained enough metal to fill all the grooves of one mould.

As to the advantage of the Bitterfeld process over the Werden process — Mr. Pilz stated that the process was much cheaper as it eliminated the manufacture of the tubes and the opening of same.

According to Mr. Pilz, after the flint rods were finished they were put into a frazing machine and then put into a cutting machine and cut into flint lengths.

Mr. Pilz had a letter which he received from his representative in Dresden indicating that the Russians had removed two — thirds of the equipment for making the metal and manufacturing the flints from the Bitterfeld plant. He believes the Russians continued the manufacture of flints when they first took over the plant but then ceased operations. He had an indication that the manufacture would be resumed in July or August at Bitterfeld.

As we had suspected, after examining the ruins of the plant at Werden, the plant there was used only for the packing and shipping of flints. Part of the flints were packed in bulk in kilo cans and partly in small packages and display cards. Mr. Pilz estimated that their production as received from Bitterfeld was between 50,000 and 60,000 kilos yearly. In the last years of the war up to the time of destruction of the plant and for a period of one or two years, the production reached 100,000 kilos. Before the end of the war due to the lack of raw materials the production dropped to the rate of 24,000 kilos annually.

As regards prices for flints the domestic price was originally between 23 and 25 marks per kilo; in 1927 an international syndicate was formed and the price was gradually increased to 29.4 marks per kilo. This was equivalent to 178 francs, the francs being used as a base due to the devaluation of the dollar at that time. The head of this syndicate was a Mr. Anweiler.

Mr. Pilz estimates the world consumption of flints as 200,000 kilos annually.

TREIBACHER CHEMISCHE WERKE A. G.,
TREIBACH-KAERNTEN, AUSTRIA.

(1—3 Aug. 1946)

This target was visited by a British Team on 28 September 1945 (BIOS Trip No. 1226) and reference is made to detailed report FR No. 400 "The Cerium Industry in German Territory".

It would serve no purpose to duplicate the information contained in the BIOS report so, as far as possible, only such new or additional information as was obtained will be included herein.

I. Raw Materials for making Misch Metal.

This company produced misch metal from anhydrous rare earth chloride received from the Auergesellschaft, Berlin. As this source of supply has been cut off they have had to seek new raw materials. Presently they are working up a small quantity of monazite sand which they had in stock along with residues which have been accumulating for many years.

From 1940 on they received only limited quantities of anhydrous chloride from Auergesellschaft and they began to work up some of their residues and added the material thus obtained to the Auer product.

The following table shows the ratio of anhydrous rare earth chloride used to misch metal produced. It will be noted that the chloride consumption per kg. of misch metal increased substantially as soon as a mixture was used.

Year	kgs. Anhydrous Chloride Used.	kg. Misch Metal Ratio Produced	kgs. Chloride to Metal
1935	71009	31446	2.26
1936	13273	37578	2.22
1937	125545	55000	2.28
1938	61868	27130	2.28
1939	130659	61400	2.13
1940	173467	70756	2.24*
1941	145732	63200	2.30*
1942	77598	32882	2.36*
1943	93007	33474	2.79*
1944	57842	21680	2.68*

* Mixture of Auer and Treibach chloride.

The company has placed an order for Vacuum Drying equipment in Switzerland for drying the rare earth chloride made from their present residues. No plans of this dryer were available. It was stated that the drying is to be done in two stages. In the first stage a temperature of about 170° C is used while in the second stage superheated steam at about 350° C is employed.

The following specification was furnished as representative of a high grade of hydrous rare earth chloride of the quality furnished by Auergesellschaft.

1. Total rare earth oxide 45% in which the ratio of pure cerium oxide to total rare earth oxide is 50%.
2. Reaction neutral.
3. $PbCl_2$ less than 0.075%.
4. $FeCl_2$ less than 0.8%.
5. $AlCl_3$ less than 0.5%.
6. $BaCl_2$ (+ $SrCl_2$) less than 0.3%.
7. $CaCl_2$ less than 2.5%.
8. $MgCl_2$ less than 0.3%.
9. NaCl less than 1.5%.
10. Practically free from S, P, H_2SO_4, P_2O_5, SiO_2 that is, less than 0.05%.

2. Stocks of Raw Materials as of January 30, 1946.

The following figures were given:

(a) 30,000 Kgs. CeO_2 to be transformed into anhydrous cerite chloride pls 5500 kgs. of cerite chloride available.

(b) 12,000 Kgs. cerium misch metal.

3. Production of Flints.

Monthly production of flints (Auer Metal) about 1200 Kgs. at present. The following production figures (Kg.) were obtained:

1934—27,000	1940—71,000
1935—30 000	1941—72 000
1936—32 000	1942—41 000
1937—54 000	1943—34 000
1938—21 000	1944—20 000
1939—71 000	1945— 7 300

First 6 months 1946—6000

4. Sales Flints May 1 — Dec. 31. 1945 (Kgs).

Styria and Burgenland	1996.66
Carinthia	2608.61
Lower Austria	368.75
Upper Austria	578.30
Tirol and Vorarlberg	422.82
Salzberg	204.56
Total	6179.70

5. Misch Metal Sales and Uses.

The policy of the company was to use entire production of cerium misch metal for making lighter flints.

The following sales of cerium misch metal were made, however, during the periods indicated:

1941 — 613 Kg.
1942 — 547 Kg.
1943 — 1756 Kg.
1944 — 151 Kg.

It is believed by Treibach that these quantities were used for making special heat resistant metals such as iron-nickel alloys and magnesium alloys.

Treibach has had no experience making cerium misch metall powders. They produced experimentally small amounts of powdered ferro-cerium. This was done by breaking flints under a hammer in a drum.

Treibach has had no experience in making cerium alloys other than Ferro-Cerium for lighter flints.

INFORMATION ON I. G. F. BITTERFELD MANUFACTURE OF LIGHTER FLINTS.

(Translation of a German Report)

DESCRIPTION OF THE PRODUCTION OF CERZUENDMETALL

Designation and Properties of the Finished Product:

Technical designation — Zuendmetall

Trade name — Zuendstein

Zuendmetall is an alloy of the following composition: mischmetall 76%, iron 16%, copper 4%, magnesium 2% and tin 2%.

Special property, pyrophoric. Melting point about 1000° C. Ignition temperature, 150—200° C. Specific gravity, 6.6. Usual commercial form, little sticks of 2.6 mm diameter × 5 mm long and 3 mm diameter × 20 mm long.

Color:

Natural color or Al-bronze coated.

Uses:

For the ignition of gases and vapors, in cigarette lighters and the gas lighter industry.

Starting Materials:

No.	Material	Specification	Remarks
1	Mischmetall	Mischmetall 98.7% Fe + Al 1.1% Si 0.2%	Produced in own works.
2	Iron	Finely divided clean scrap.	Nail scrap.
3	Copper	Bus bar chips.	Produced in own works.
4	Magnesium	Pure magnesium chips.	Produced in own works.
5	Tin	Block tin.	Foreign.
6	Potassium chloride	Flux	From I. G. Farben.
7	Barium chloride	Flux	From I. G. Farben.

Manufacture:

The manufacture is done in the following sequence:

Melting of the alloy
Assembly of the mold
Pouring of the alloy
Opening of the molds
The removal of the cast alloy
The grinding of the flints
Cutting of the flints
Coloring the flints
Sorting of the flints.

Description of the Process:

The alloy is melted in an electric resistance furnace of the Helberger type. Graphite-clay crucibles with a content of 30 kg., calculated on iron, are used. After placing the crucible between the carbon contact heads of the furnace, 3 kg. of a salt mixture, potassium chloride: barium chloride 2 to 1, are added and melted. Finally, 11.06 kg. of mischmetall are added and the current adjusted to 14 volts at 1500 amp. After the mischmetall is melted, 2.14 kg. of iron is charged. When this is melted 0.28 kg. of magnesium is added and just before pouring 0.24 kg. of tin is stirred in. The melting process takes about 50 minutes, the melting temperature being 1000° C. After melting, the crucible is removed from the furnace and a part of the slag, especially that not molten, is removed.

In the meantime, the mold is heated with its built-in gas burner using hydrogen produced as a by-product from alkali electrolosis from our own plant. The temperature of the mold should be from 500 to 600° C. The mold consists of 8 parts set up in the form of a star. Each part is a cast iron split mold, and they are so connected that a pouring channel of about 20 mm diameter feeds all eight. The eight split molds are held tightly together between a cast iron foot plate and cover plate

by means of screws and wedges to form a tightly closed assembly. Each split mold consists of two flat plates in which 60 to 70 horizontal grooves have been milled, slightly increasing in diameter toward the outside. The channels formed in the split molds are almost hermetically sealed by clamping strips of sheet iron on the joints, in order to avoid squirting out of the metal. A steel funnel is screwed on to the top plate of the star, communicating with the main pouring channel. Its top contains an asbestos packing; with the aid of a pressure lever the top can be tightly closed by hand. After first pouring off a part of the slag as previously mentioned, the liquid metal is poured into the funnel, the top is closed and tightly sealed by hand. Now, compressed air of 4 to 5 atmospheres is applied to the funnel whereby the asbestos packing between the top plate and the funnel is blown out, allowing the metal to be forced into the channels of the mold.

After the mold has cooled to about 150° C it is taken apart. The split molds are unclamped and the metal sticks removed. In order to prevent the metal baking into the molds they are thoroughly cleaned with a steel brush and then sprayed with a suspension of fine magnesium in magnesium-containing water. This avoids the formation of any crusts so that the dimensions of the sticks will not vary.

The cast sticks are cleaned of slag by hand and ground to the desired dimensions. The grinding is done in a straight cylindrical grinding machine made by Herninghausen, Hannover, Wuelfel. The capacity of a double grinding machine is 18 kg. per hour for 2.6 mm diameter sticks and 25 kg. per hour for 3 mm diameter sticks. The ground sticks are next brought to the desired length by cutting machines. The capacity of these machines is from 17 to 20 kg. per hour depending upon the diameter. After cutting, the metal is either tinted with dilute nitric acid or colored with aluminum-bronze. The latter is done by introducing a little varnish, then the aluminum bronze powder is added and the flints are shaken in a box until the desired aluminum coat is obtained.

The metal is finally sorted, this being done by passing the metal over conveyor belts, the faulty pieces being sought out by hand.

Supervision of the Operation:

Grab samples of the sticks are examined by the foreman for every pouring. The surface condition and cleanliness of the pouring is thus determined. Also, samples are taken from the grinding machine and from the cutting machine every hour and the dimensions tested with a micrometer. The permissible variation is ± 0.05 mm diameter and ± 0.1 mm in length.

Material Consumption:

No.	Raw Material or Form of Energy	Unit	Quantity consumed per 1000 kg. of finished product
1	Mischmetall	Kg.	950
2	Iron	Kg.	190
3	Copper	Kg.	24
4	Magnesium	Kg.	27
5	Tin	Kg.	20
6	Current	KWH	13080
7	Graphite Electrodes	Kg.	120
8	Graphite Crucibles	Crucible	15
9	Hydrogen	Cubic meters	9440
10	Potassium chloride	Kg.	220
11	Barium chloride	Kg.	100

By-Products:

There are no by-products since all scrap, grindings and the like are worked up in the process.

Accid nt and Fire Protection, and Guarding of the Workers Health:

In assembling the mold care must be taken that all places from which the metal can squirt out are carefully tightened. In order to prevent burns from working the metal the mold is surrounded by a sheet iron mantle. Also, the pouring funnel is protected by a sheet iron caseing. The two workers who do the pouring must wear leather or asbestos aprons. The melting furnace must be thoroughly ventilated to carry off barium chloride vapors.

Description of Storage of Raw Materials and Finished Products:

The raw material is stored in barrels. Only plates of mischmetall as such is stored loose in a dry room. The finished products are always stored in sheet iron boxes in iron cupboards.

The shipment of the flints is done in sheet iron boxes and sheet iron cans or in wooden boxen lined with sheet iron.

Analytical Methods:

Silicon estimation:

Two to 2.5 grams are dissolved in 30 ml of concentrated HCl and 5 to 10 ml concentrated HNO_3, then evaporated to dryness. After bringing to dryness twice with HCl the SiO_2 is filtered out and weighed as usual.

Tin, Copper, Iron, Aluminum, Magnesium and Cerium Estimation:

One to 1.5 grams are dissolved in 20 ml concentrated HCl then oxidized with bromine water. The bromine is boiled out, the solution is diluted to 200 ml and H_2S introduced. Sn and Cu precipitate as sulphides. The precipitate is filtered out and washed with H_2S water, then the precipitate together with the filter is returned to the precipitation beaker and dissolved in 50 ml of 1:1 HNO_3. The solution is then diluted to 200 ml with hot water and brought to boiling. The precipitate is allowed to settle, is filtered, washed with hot ammonium nitrate water, dried, ignited and weighed as SnO_2. The filtrate from the SnO_2 is fumed with 10 ml H_2SO_4, cooled, diluted to 100 ml with water and made ammoniacal. It is then made acid with HCl and the copper precipitated with H_2S. The precipitate is washed with H_2S water, dried, ignited and weighed as CuO.

The filtrate from the H_2S precipitation is boiled, oxidized with bromine water and the Ce, Fe and Al precipitated twice with ammonia. The precipitate is dissolved with HCl and the cerium is precipitated from the slightly acid solution as oxalate. It is allowed to stand for twelve hours then filtered and washed with hot water containing oxalic acid. It is then dried, ignited, and weighed as CeO_2.

The filtrate from the oxalate precipitation is treated with 10 grams of ammonium persulphate, boiled and evaporated to 100 ml. HNO_3 is next added and iron and aluminum precipitated with ammonium. The iron is titrated in the usual manner and the aluminum estimated by difference.

In the filtrate from the double ammonia precipitation magnesium is determined as pyrophosphate in the usual manner.

LIST OF APPARATUS INSTALLED

Name	Material	Number Installed	Description	Size	Remarks
Melting furnace	Iron	3	To take 4.5 liter crucibles	—	Made in own works
Shaft furnace for pre-heating the mold	Iron	4	—	1350 mm diam. × 1350 mm deep	Made in own works
Molds	Cast iron	4	1 pouring takes 8.5 Kg. metal	—	Made in own works
Electric Hoist	—	1	—	2,590 Kg.	
Split molds	Cast iron	—	—	—	Made in own works
Shear	Iron	1	For trimming the ends of the sticks	65 mm knife	Made in own works
Grinding machine	Iron	2	Straight double cylindrical, 18—25 Kg./hr.	400 mm diam. grinding wheel	Herminghausen Hannover-Wuelfel
Cutting machine	Iron	5	17—20 Kg./hr. capacity	Cuts 15 sticks at a time. Knife size 90 × 60 mm	Made in own works
Coloring apparatus	Iron	1	Heated shaking box	Box is 500 × 300 mm	Made in own works
Sorting machine	Iron and wood	5	Sorting belt — 350 × 270 mm	Capacity 100 Kg./8 hrs.	Made in own works

APPENDIX 1

LIST OF GERMAN PERSONNEL INTERVIEWED

Name	Position	Location
Mr. Heinrich Paetsch	Managing Director	Auergesellschaft Berlin N 65 Friedrich-Krauser Ufer 24
Mr. Paul Wagner	Assistant Director	Auergesellschaft Berlin N 65 Friedrich-Krauser Ufer 24
Dr. Ihwe	Chief Chemist	Auergesellschaft Berlin N 65 Friedrich-Krauser Ufer 24
Mr. Mueller	Managing Director	Berliner Gasgluehlicht Werke Berlin N 65 Friedrich-Krauser Ufer 24
Mr. I. Paetsch	Foreman	Berliner Gasgluehlicht Werke Berlin N 65 Friedrich-Krauser Ufer 24
Dr. Theo. Goldschmidt	President	Th. Goldschmidt A.G. Essen Heilermann Str. 15
Dr. H. Schertel	Metallurgist	Th. Goldschmidt A.G. Essen Heilermann Str. 15
Prof. Bungardt	Consultant	Th. Goldschmidt A.G. Essen Heilermann Str. 15
Mr. Andreas Maier-Oswald	Custodian	Prometheus Kempten im Allgaeu Bavaria
Mr. Frederick Schweighofer	Technical Manager	Prometheus Kempten im Allgaeu Bavaria
Mr. Bernhard Pilz		Pyrophor Metall- gesellschaft A.G. Essen-Werden

APPENDIX 2

LIST OF TARGETS VISITED

Name	Location
Auergesellschaft	Berlin N 65 Friedrich-Krauser Ufer 24
Berliner Gasgluehlicht Werke (Richard Goetachke A.G.	Berlin N 65 Friedrich-Krauser Ufer 24
Th. Goldschmidt A.G.	Essen, Heilermann Str. 15
Prometheus	Kempten im Allgaeu Bavaria
Pyrophor Metallgesellschaft A.G.	Essen-Werden
Treibacher Chemische Werke A.G.	Treibach-Kaernten, Austria

APPENDIX 3

BIBLIOGRAPHY

Copies of the reports, documents and microfilm listed below were transmitted to Washington, D. C. Inquiries should be addressed to:

Office of Publication Board,
U. S. Department of Commerce,
Washington 25, D. C.

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BIOS F. R. No. 400 "The Cerum Industry in German Territory including Reports on Radium and Mesothorium" by R. Singer, H. E. Airey, L. C. Grimmett, H. R. Leech and R. Bennett, located at FIAT Records Branch, File TN 760/P 113.

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